EFFECTIVENESS OF GUNNERY AND ROBOTIC CONTROL PERFORMANCE IN A SIMULATED MULTI-TASKING ENVIRONMENT

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ABSTRACT

In this study, we simulated a generic mounted crewstation environment and conducted an experiment to examine the workload and performance of the combined position of gunner and robotic operator. Results showed that gunner's target detection performance degraded significantly when s/he had to concurrently monitor, manage, or teleoperate an unmanned ground vehicle compared to the baseline condition (gunnery task only). Additionally, those with higher spatial ability (as measured by Spatial Orientation Test) performed significantly better than those with lower spatial ability. For the robotic tasks, participants detected significantly fewer targets when their robotic asset was semi-autonomous instead of teleoperated, indicating over-reliance on the aided target recognition capabilities available when task load was heavy (i.e., concurrent performance of the gunnery task). Participants' perceived workload increased consistently as the concurrent task conditions became more challenging. Finally, those with higher perceived attentional control performed better on a concurrent communication task in the more difficult tasking conditions. Implications for military personnel selection were discussed.

1. INTRODUCTION

1.1 Background

The goal of this research was to examine whether gunners in a U.S. Army Future Combat System (FCS) manned vehicle were able to effectively maintain local security (i.e., perform their gunner's tasks) while managing their unmanned assets and if/how individual difference factors such as attentional control and spatial ability had any impact on the performance. Mitchell (2005) examined workload for the Mounted Combat System (MCS) crew members using a task-network modeling tool, Improved Performance Research Integration Tool (IMPRINT). According to Mitchell, the gunner is the most viable option for controlling robotic assets compared to the other two positions (i.e., commander and driver). She found that the gunner had the fewest instances of overload and could assume control of the robotic tasks. However, she also discovered that there were instances in the model when the gunner dropped his primary tasks of detecting and engaging targets to perform robotic control tasks, which could be catastrophic for the team and mission during a real operation.

Past research in dual task performance suggests that operators may encounter difficulties when both tasks involve focal vision (Horrey & Wickens, 2004). Horrey and Wickens (2004) demonstrated that participants could not effectively detect road hazards while operating in-vehicle-devices. Additionally, research on visual performance demonstrated that as the size of the search set increased, performance degraded in terms of either speed or accuracy or both (Scanlan, 1977). Murray (1994) showed that as the number of monitored displays increased, operators' reaction time for their target search tasks also increased linearly. In fact, reaction time almost doubled when the number of displays increased from 1 to 2 and from 2 to 3 (a slope of 1.94 was obtained).

According to Wickens, Dixon, and Chang (2003), visual angle separation larger than about 6.4 ~ 7.5 degrees may degrade event monitoring response time. In the case of concurrent performance of gunner's and robotic operator's tasks, it was expected that performance would be worse than when the operator only had to perform one task since concurrent tasks involved more displays to visually scan. It was expected that the gunner's task performance would further degrade when the robotic tasks became more challenging. For example, when robots needed teleoperation and/or when the operator needed to use the user interface to perform some tasks (e.g., putting targets on the map, labeling the targets, sending spot-reports, etc.). Moreover, research has shown that increased mental workload could reduce the size of operator's visual field (Rantanen & Goldberg, 1999). It was expected that the reduced visual field would have a significant impact on the operator's gunnery task performance (i.e., target detection in his immediate environment).

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1.2 Current Study

This current research tried to verify the modeling project's analytical results (Mitchell, 2005) and examined whether the gunner could effectively detect targets in his or her immediate environment while operating robotic assets in a remote environment. In this study, we simulated a generic mounted crewstation environment and conducted an experiment to examine the workload and performance of the combined position of gunner and robotic operator. The experimental conditions included a Gunner Baseline condition and 3 concurrent task conditions where participants simultaneously performed gunnery tasks and one of the following tasks: monitor an unmanned ground vehicle (UGV) via the video feed (Monitor condition), manage a semi-autonomous UGV (UGV condition), and teleoperate a UGV (Teleop condition).

Participants also performed a tertiary communication task concurrently, which simulated gunner's communication with fellow crew members in the vehicle. Richard et al. (2002) found that participants' change detection was negatively affected by a concurrent auditory task. More specifically, participants' reaction times were slower and visual scanning was less effective. In the current study, we expected the concurrent communication to have a similar negative effect on participants' target detection performance. Although we did not manipulate the communication task as a variable, we tried to examine if participants with higher attentional control could perform their tasks more effectively than those with lower attentional control in our simulated multi-tasking environment. Schumacher et al. (2001) demonstrated that some participants were more effective in concurrently performing a visual task and an auditory task but did not examine what individual difference factor(s) contributed to that time sharing effectiveness.

In the current study, it was expected that performance would be worse in the concurrent task conditions because of the divided visual attention, and that the gunner's task performance would further degrade when the robotic tasks became more challenging (i.e., when more than mere monitoring was needed). Participants' robotic task performance was expected to differ depending on the type of asset available and the type of task they were asked to perform. Chen, Durlach, Sloan, and Bowens (in press) demonstrated that participants' target detection was significantly lower when they had to teleoperate the unmanned ground vehicle (UGV) as compared to when the UGV was semi-autonomous. Chen et al. suggested that maybe participants' teleoperation (i.e., driving the robot) negatively affected their target detection performance. Luck, Allender, and Russell (2006) reported that robotic operators' situational awareness was better when the small UGV had a higher level of automation. Luck et al. suggested that the attention on (manual) robotic control might have distracted the operators from focusing on the vehicle's location, which was the study's measure of situational awareness. Dixon, Wickens, and Chang (2003) also reported that pilots found more targets when their unmanned aerial vehicle(s) were autonomous than when they were teleoperated.

Finally, the relationship between participants' spatial ability (SpA) and their task performance was examined. According to Chen et al. (in press), those with higher SpA performed target detection tasks using robotic assets more effectively than those with lower SpA. In the current study, two different types of spatial tests were employed. It was expected that those with higher SpA test scores would perform their robotic tasks better.

2. METHOD

2.1 Participants

A total of 20 students (3 females and 17 males) were recruited from the University of Central Florida and participated in the study. The ages of the participants ranged from 18 to 45 (M = 20.8, SD = 3.2). Participants were compensated $40 and class credit for their participation in the experiment.

2.2 Apparatus

2.2.1 Simulators

The experiment was conducted using the Tactical Control Unit (TCU) developed under Army Research Laboratory's Robotics Collaborative Technology Alliance (RCTA) for the robotic control tasks. The gunnery component was implemented using an additional screen and controls to simulate the out-the-window view and both line-of-sight (LOS) and beyond-line-of-sight (BLOS) fire capabilities (see Fig. 1).

Fig. 1. TCU (left) and Gunnery station (right).

The RCTA TCU is a one-person crew station from which the operator can control several simulated robotic assets, which can either perform their tasks semi-autonomously or be teleoperated. The operator switched operation modes and display modes through the use of a 19” touch-screen display. A joystick was used to manipulate the direction in which the unmanned vehicles moved when in Teleop mode. The UGV simulated in our study is the eXperimental unmanned vehicle (XUV) developed by the Army Research Laboratory. The simulation program used in this study was rSAF, which is a version of OneSAF for robotics simulation.

The gunnery component consisted of a monitor and a joystick. The interface consists of a 15” KOGi flat panel monitor and a joystick. Participants used the joystick to rotate the sensors 360 degrees, zoom in and out, switch between firing modes, and engage targets. For engaging BLOS targets, the participants would need to receive authorization from the vehicle commander (i.e., the experimenter) and then line up his or her aim with the direction of the target (the line would turn red when it was aiming at the target) and then fire.

Cognitive tests were administered concurrently with the experimental sessions. The questions included simple military-related reasoning tests and simple memory tests. The inclusion of these cognitive tasks was for simulating an environment where the gunner was communicating with fellow crew members in the vehicle. For the reasoning tests, there were questions such as “if the enemy is to our left, and our UGV is to our right, what direction is the enemy to the UGV?” For the memory tests, the participants were asked to repeat some short statements or keep track of three radio call signs (e.g., Bravo 83) and they had to report to the experimenter whether the call signs they heard were one of those they were keeping track of. Test questions were delivered by a synthetic speech program, DECTalk®. The questions were pre-recorded by a male speaker and presented at the rate of one question approximately every 33 seconds.

2.2.2 Questionnaires and Tests

A demographics questionnaire was administered at the beginning of the training session. A questionnaire on Attentional Control (Derryberry & Reed, 2002) was used to evaluate participants’ perceived attentional control. The Attentional Control survey consists of 21 items and measures attention focus and shifting. The Cube Comparison Test (Educational Testing Service, 2005) and the Spatial Orientation Test were used to assess participants’ spatial ability. The Cube Comparison Test required participants to compare, in 3-minutes, 21 pairs of 6-sided cubes and determine if the rotated cubes were the same or different. The Spatial Orientation Test, constructed by Dr. Paula Durlach of the U.S. Army Research Institute, is modeled after the cardinal direction test developed by Gugerty and his colleagues (Gugerty & Brooks, 2004) and is a computerized test consisting of a brief training segment and 32 test questions. Both accuracy and response time were automatically captured by the program. Participants’ perceived workload was evaluated using the NASA-TLX questionnaire (Hart & Staveland, 1988). The NASA-TLX is a self-reported questionnaire of perceived demands in nine areas: mental, physical, temporal, effort (mental and physical), frustration, performance, visual, cognitive, and psychomotor. Participants were asked to evaluate their perceived workload level in these areas on 10-point scales.

The Simulator Sickness Questionnaire (SSQ) was used to evaluate participants’ simulator sickness symptoms (Kennedy, Lane, Berbaum, & Lilienthal, 1993). The SSQ consists of a checklist of 16 symptoms. Each symptom is related in terms of degrees of severity (none, slight, moderate, severe). A total severity score can be derived by a weighted scoring procedure and reflects overall discomfort level.

Finally, a usability questionnaire was constructed, based on the one used in the Unmanned Combat Demonstration (UCD) study (Kamsickas, 2003). Specifically, the questionnaire included the following sections: asset summary, Reconnaissance, Surveillance, and Target Acquisition (RSTA), map display, teleoperation, reporting, and general usability of the TCU. Participants indicated their level of agreement with the items using 7-point numerical scales. Participants were also given an opportunity to provide comments to support or clarify their numeric responses. The comments, in addition to the numeric responses, provided the researchers with further insight as to the participants’ opinions about the crewstation.

2.3 Procedure

After the informed consent process, participants filled out the Attentional Control Survey and were administered the Cube Comparison Test and the Spatial Orientation Test. After these tests, participants received training, which lasted approximately two hours. The experimental session took place on a different day but within a week of the training session. Each experimental session lasted approximately 15 minutes, and the order of experimental conditions was counterbalanced across participants. For the Gunner Baseline condition, the operator performed only gunnery tasks (i.e., target detection and engagement). In the remaining conditions, the operator performed gunnery tasks and one of the following robotic tasks: monitor the video feed and verbally report any targets detected (Monitor condition); monitor the video feed, examine still images generated from the reconnaissance scans, which were enabled by the aided target recognition (ATR) capabilities, and detect targets (UGV conditions); and manually manipulate the UGV along a predetermined route to detect targets (Teleop conditions). There were two-minute breaks between experimental sessions.

While the participants were performing gunnery and/or robotic control tasks, they performed the communication tasks (i.e., cognitive test) simultaneously. For the purpose of comparing participants' robotic control task performance between the single-task and concurrent-task conditions, we added a UGV-Baseline condition to half of the participants and Teleop-Baseline to the other half of the participants. In these two conditions, they did not have to perform the gunnery tasks and only had to simultaneously perform the robotic control tasks and the communication tasks.

Participants filled out the NASA-TLX after the four main experimental conditions and the SSQ at the end of the experimental session.

2.4 Experimental Design and Measures

The overall design of the study is a repeated-measures design. There were four conditions:

- Gunnery Baseline *(Gunner Baseline)*
- Concurrent task conditions:
    - Monitor: Gunnery + Monitoring 1 Semi-autonomous UGV *(Monitor)*
    - Gunnery + Monitoring + Control of 1 Semi-autonomous UGV *(UGV)*
    - Gunnery + Monitoring + Teleoperating UGV *(Teleop)*

The dependent measures include mission performance (i.e., number of targets detected in the remote environment using the robotic assets and number of enemy targets detected in the immediate environment), communication task performance, and perceived workload.

3. RESULTS

3.1 Target Detection Performance

3.1.1 Gunnery Tasks

Correlations between participants' gunnery task performance and their Attentional Control Survey, Cube Comparison Test, and Spatial Orientation Test scores were first evaluated. The Spatial Orientation Test scores were found to be the most accurate predictor of participants' gunnery performance, with Gunner Baseline, Monitor, and Teleop conditions being significant (p's < .05). Participants were then designated as high SpA or low SpA based on their Spatial Orientation Test scores. A mixed Analysis of Variance (ANOVA) was performed, with the Asset condition (Gunner Baseline, Monitor, UGV, Teleop) being the within-subject factor and SpA (Spatial Orientation Test score) as the between-subject factor. The analysis revealed that Asset condition significantly affected number of targets detected, $F(3, 16) = 28.417$, $p < .0001$, with Gunner Baseline being the highest and Teleop being the lowest. Participants with higher SpA had significantly higher gunnery task performance than did those with lower SpA, $F(1, 18) = 8.76$, $p < .005$ (Fig. 2).

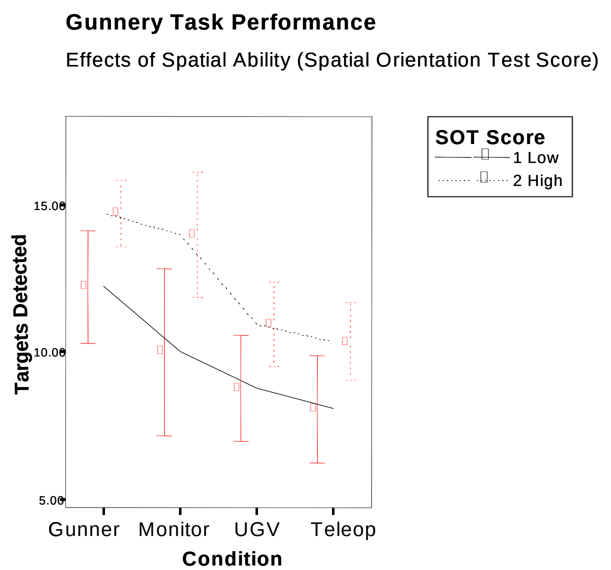

Fig. 2. Gunnery task performance.

3.1.2 Robotic Tasks

Correlations between participants' target detection performance on the robotic tasks and their Attentional Control survey, Cube Comparison Test, and Spatial Orientation Test scores were first evaluated. No consistent significant correlations were observed.

Two repeated-measures ANOVAs were performed to compare participants' target detection performance on the robotic tasks, one for the human targets and the other for the vehicle targets. The first analysis showed that there were significant differences among the Monitor, UGV, and Teleop conditions in human target detection, $F(2, 18) = 4.794$, $p < .05$, with UGV being the lowest. Post-hoc tests (LSD) showed that differences between Monitor and UGV and between Teleop and UGV were both significant. The second analysis examined the difference between the UGV and the Teleop conditions in vehicle target detection and the difference was not significant.

To further examine why the Teleop condition produced better target detection rates than the UGV condition, which conflicted with the findings in Chen et al. (in press), we compared the number of targets detected along the route and targets detected within RSTA areas for the UGV and Teleop conditions. A 2 x 2 repeated measures ANOVA was performed with Asset condition (UGV vs. Teleop) and Target Location (Route vs. RSTA) as the factors. The analysis revealed that both effects were significant: Asset, $F(1, 38) = 5.75$, $p = .019$; Location $F(1, 38) = 18.01$, $p < .0001$. Post-hoc tests showed that the largest difference in targets detected was along the route, with UGV having a 35% and Teleop 51% target detection rate.

Half of the participants also completed the UGV-Baseline condition and the other half Teleop-Baseline condition so we could compare if participants target detection performance degraded when they had to perform the gunnery task concurrently. Results showed that when participants only had to operate the UGV, their overall target detection rate (including both human and vehicle targets) was 80%; when they had to concurrently operate the UGV while performing the gunner's tasks (i.e., UGV condition), their target detection using the UGV dropped to 67% (difference close to significance).

3.2 Communication Task Performance

The differences in participants' communication task performance among the four conditions were significant, $F(3, 16) = 6.574$, $p < .005$, with the Gunner Baseline and Monitor conditions being higher than the other two conditions. Participants' perceived attentional control scores were found to be positively correlated with the communication performance in the Teleop conditions, $r = .476$ ($p = .023$). For the UGV condition, the correlation was close to significance, $r = .385$ ($p = .057$).

3.3 Perceived Workload

Participants' self-assessment of workload was significantly affected by Asset condition, $F(3, 17) = 65.102$, $p < .0001$, with Teleop ($M = 43.03$) being the highest and Gunner Baseline ($M = 22.35$) being the lowest (Fig. 3). The only individual difference factor that was significant was participants' Cube Comparison Test score, $F(1, 18) = 6.995$, $p < .05$. Those with higher test scores had *higher* perceived workload than did those with lower scores.

3.4 Simulator Sickness

Participants' Simulator Sickness Questionnaire (SSQ) scores were calculated based on the formulae in Kennedy et al. (1993). The average total severity score was 29.36 ($SD = 24.06$). Further examination of the sub-

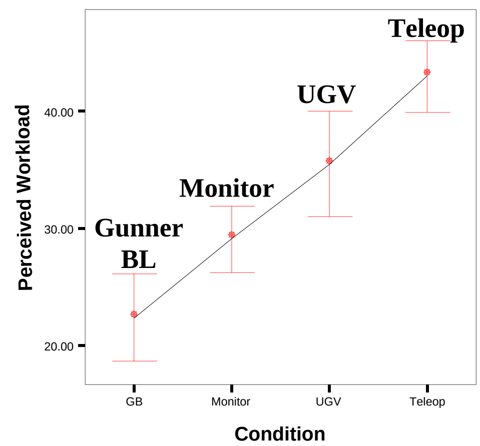

Fig. 3. Perceived workload.

scale data indicated that the oculomotor aspect significantly contributed to the elevated total severity score. Correlations between SSQ scores and perceived attentional control were consistent and mostly significant, $r = -.612$, $r = -.425$, $r = -.432$ ($p = .003$, $p = .035$, $p = .032$) for nausea, oculomotor, and total severity score, respectively. Correlations between SSQ and Spatial Orientation Test scores were also all negative but not significant (all p's > .05).

3.5 Usability Questionnaire

Generally, the TCU was perceived to be user friendly. However, a number of participants did suggest that it required too many steps to complete some simple tasks and they needed to go to different screens to complete those steps (e.g., putting targets on the map, labeling the targets, and sending spot reports). While they were completing those steps, they could not effectively monitor the gunnery station. If these steps can be more consolidated and centralized, this part of the robotic task would not require as much visual attention as it currently does.

4. DISCUSSION

In this study, we simulated a generic mounted crewstation environment and performed an experiment to examine the workload and performance of the combined position of gunner and robotic operator. Results showed that gunner's target detection performance degraded significantly when he or she had to concurrently monitor, manage, or teleoperate a UGV. The gunner's performance in the three concurrent-task conditions was all significantly different from one another, with the Monitor condition being the highest and Teleop condition being the lowest. Participants' SpA as measured by their Spatial Orientation Test scores was found to be an accurate predictor of their gunnery performance. These results suggest that, if it is necessary for the gunner to concurrently access information from the robotic assets, the robotic tasks should be limited to activities such as monitoring. If excessive manipulation of the Warfighter-machine interface is required as in the UGV and Teleop conditions, their gunnery performance will be significantly affected. When selecting personnel for these tasks, it might be beneficial to take into account their SpA. Thomas and Wickens (2004) showed that there were individual differences in scanning effectiveness and its associated target detection performance. However, Thomas and Wickens (2004) did not examine the characteristics of those participants who had more effective scanning strategies. Results of the current study suggest that spatial tests like the Spatial Orientation Test might be useful in examining individual differences in scanning behavior and target detection performance.

Further research should also examine the difference between the Spatial Orientation Test and the Cube Comparison Test. Based on the results of the current study, it appears that these two tests tapped different aspects of SpA. Some cognitive modeling work done by the Army Research Laboratory, Human Research & Engineering Directorate researchers suggested that the Cube Comparison Test may reflect ability more associated with feature comparison than with spatial rotation (Kelley, Wiley, & Lee, 2000). Verbal protocol obtained from research participants in Kelley et al. indicated that participants used a variety of problem-solving strategies for their spatial rotation test instead of mentally rotating the images.

For the robotic tasks, there were significant differences among the Monitor, UGV, and Teleop conditions in human target detection performance, with the UGV being the lowest (only 53% were detected). The inferior performance associated with the semi-autonomous UGV seemed to reflect participant's over-reliance on the aided target recognition (ATR) capabilities and failure to detect more targets along the route that were not picked up by the ATR. In contrast, in Chen et al. (in press), participants had the lowest target detection using the Teleop. However, in Chen et al.'s UGV condition, the ATR capabilities were not available. Results of the current study are consistent with automation research that operators may develop over-reliance on the automatic system and this complacency may negatively affect their task performance (Parasuraman, Molloy, & Singh, 1993). Thomas and Wickens (2000) showed that, when participants had access to information gathered from automatically panning cameras, they tended to prematurely close the automatic panning feature prior to finishing examining the entire environment. Participants manually panning the cameras, on the other hand, had significantly higher target detection performance, which indicated more adequate panning. It is worth noting that these findings along with the results of the current study do not necessarily suggest that manual manipulation of sensor devices be used instead of ATR or auto-panning devices. However, the issue of over-reliance on these automatic capabilities needs to be taken into account when designing the Warfighter-machine interface where these features are one of the components.

When participants only had to operate the UGV (i.e., UGV baseline), their overall target detection rate was 80%; when they had to concurrently operate the UGV while performing the gunner's tasks (i.e., UGV condition), their target detection using the UGV dropped to 67%. It also appears that the performance difference between UGV and Teleop widened in the concurrent task conditions compared with the single-task (baseline) conditions. In other words, the UGV-Baseline and Teleop-Baseline were at similar levels but UGV-Concurrent was significantly lower than Teleop-Concurrent. These results suggest that as operator's tasks become more challenging (i.e., concurrent conditions), he or she may rely more on the ATR capabilities to relieve the workload if they are available. However, the over-reliance on the ATR capabilities may result in overall performance degradation as discussed in the previous paragraph.

None of the individual difference factors were found to significantly correlate with participants' robotic task performance. The lack of correlation between SpA and robotic task performance was unexpected. Chen et al. (in press) showed that those with higher SpA (as measured by the Cube Comparison Test) had significantly higher performance in their target detection task using the UGV. Further research is needed to examine the relationship between SpA and robotic task performance.

Participants' communication task performance degraded when their robotic tasks became more challenging (i.e., UGV and Teleop conditions). It is interesting to note that participants appeared to be able to perform their communication task at similar levels in the Gunner Baseline and Monitor conditions. This suggests that, in the Monitor condition, participants had sufficient cognitive resources left to perform the communication tasks. Participants with higher perceived attentional control performed better on the concurrent communication task, although they performed at a similar level on their gunnery and robotic control tasks as those with lower perceived attentional control. These results suggest that participants devoted most of their attention resources to the gunnery and robotic tasks, and only those with higher attention allocation skills could more successfully perform the tertiary communication tasks. Since communication will be a critical part in the task environment, these results may have important implications for personnel selection for the Army's future forces.

Participants' perceived workload increased almost linearly in order from the Gunner Baseline, Monitor, UGV and to the Teleop condition, and the differences among the four conditions were all statistically significant. These results are consistent with Schipani (2003), which evaluated robotic operator workload in a field setting. Although many of the ground robotic assets in the Army's FCS program will be semi-autonomous, it is very likely that teleoperation will be required at times when the robotic assets encounter problems. The higher workload associated with teleoperation needs to be taken into account when designing the Warfighter-machine interfaces for the FCS. Additionally, it appears that participants with higher SpA, although performing better on the tasks, did not perceive the tasks as less demanding. In fact, the correlations between participants' perceived workload and their Cube Comparison Test scores or Spatial Orientation Test reaction times indicated that those with higher SpA (at least according to these two measures) actually perceived the tasks as *more* demanding. The correlations between participants' perceived attentional control and their workload were as expected. Those with higher attentional control thought the tasks as less demanding. It is worth noting that only in the most challenging condition (i.e., Teleop) did the correlation reach significance. In other words, as the tasks became harder, the differences in the levels of perceived workload between those with higher and lower perceived attentional control appeared to widen. The relationships between workload and perceived attentional control and SpA need to be further investigated.

Participants seemed to experience somewhat significant levels of simulator sickness, especially in the oculomotor area. The high demand of visual attention, particularly in the concurrent task conditions, may have contributed to the elevated levels of simulator sickness the participants experienced. It is worth noting that our entire experimental session only lasted about one and a half hours. Any duration longer than this may induce even more severe sickness. Participants with lower perceived attentional control had significantly higher simulator sickness than did those with higher attentional control. It was reported that, in the virtual environment, those who need to concentrate more tended to experience higher levels of simulator sickness (Regan, as cited in Kolasinski, 1995). The findings of the Regan study and the current study seem to suggest that those who are better at allocating their attentional resources may experience lower simulator sickness. Focused attention has been found to positively correlate with telepresence (Novak, Hoffman, & Yung, 2000), which is negatively correlated with simulator sickness (Witmer & Singer, 1998). Alternatively, those with lower perceived attentional control might pay more attention to (and be distracted by) their own bodily reaction. This increased awareness may have contributed to the elevated levels of simulator sickness. It is also possible that they were not experiencing more sickness but were simply more aware of the symptoms. More research in this area is needed.

CONCLUSIONS

The findings of the current study suggest that, in an FCS multi-tasking environment, if it is necessary for the gunner to concurrently access information from the robotic assets, the robotic tasks should be limited to activities such as monitoring. If excessive manipulation of the Warfighter-machine interface is necessary, as in the UGV and Teleop conditions of this study, their gunnery performance and communications with fellow crew members may be significantly affected. When selecting personnel for these dual positions, it might be beneficial to consider operator's spatial ability and perceived attentional control. Follow on studies will examine the utility of ATR-enabled alert for improving gunner dual task performance and will vary the type of alert (tactile vs. visual) and the reliability of the ATR (miss-prone vs. false alarm-prone).

The results of this experiment were consistent with the predictions generated by the modeling analysis in Mitchell (2005). More specifically, Mitchell predicted that the gunner would become overloaded if s/he has to perform the gunnery duties while concurrently operating unmanned assets, especially when teleoperation is required. Moreover, the gunner, when overloaded, may reprioritize the tasks and give higher priority to dealing with the robot and s/he will likely scan less and, therefore, jeopardize the security of the platform. Our data confirmed these predictions. In addition, we examined how various individual differences factors may affect the operator's performance. Our data on individual differences can be used in future MCS modeling efforts as input data to modeling tasks and, therefore, enhance future model analyses (Mitchell & Chen, 2006). The findings of our study have also been forwarded to the MCS design group so the data can be incorporated in their manning assessment for system functional review (Mitchell & Chen, 2006).

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